O‘AHU: ECOLOGICAL AND CULTURAL SIGNIFICANCE OF CORAL REEF ECOSYSTEMS

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Coral reefs act as the lungs of the ocean. They help feed the marine life in the sea with significant cosmogenic value to the Kānaka Maoli. Reefs have been under attack for generations. Unrestricted tourism by the millions destroys native ecosystems. Agriculture on O‘ahu contributes to the coral reefs’ destruction because of chemicals in pesticides and loose sediment that end up on the reefs. These impacts have caused major changes to the reefs on O‘ahu. It is the responsibility of local residents and tourists to care for and preserve the reefs because the reefs cannot fight for themselves. Humans must stand up for them. This study focuses on why coral reefs are important, the threats to coral reef ecosystems, current conservation methods, and proposed sustainable solutions.

Introduction

Tropical coral reefs rank among the planet’s most crucial life support systems. They provide shelter and food for different species of coral, sponges, crustaceans, fishes, and other marine life (Sheppard et al. 2018). With their vibrant colors and diverse wildlife, coral reefs exist in warm shallow ocean waters of O‘ahu (Hinrichsen 1997). Kānaka Maoli cosmogony beautifully chants a deep respect for coral reefs. The second verse in the *Kumulipo*, the Hawaiian cosmogony chant, “Kumulipo was born in the night, a male. Poele was born in the night, a female.

A coral insect was born, from which was born perforated coral" (Liliʻuokalani 1978). The *Kumulipo* identifies coral as a significant life-form in the creation of the universe; it was created immediately following the creation of humans.

According to Siler (2012), Kānaka Maoli cared diligently for coral reefs, the first of the living organisms in the connectivity between man and the natural environment. Foreigners did not show as much care for the reefs. She explains how power was formed from continental conquest and coral reefs among other fundamental native beliefs were not part of manifest destiny westward. Upon the United States' overthrow of the Kingdom of Hawaiʻi, the landscape of Oʻahu shores and coral reefs experienced dramatic change toward the introduced capitalistic model of business, altering land-based stewardship values into commodity-based land resources for exploitation Following the overthrow of the Kingdom of Hawaiʻi and statehood in 1959, government politicians introduced destination tourism to feed government funds. It can clearly be seen from Hitch (1958) that Hawaiʻi was looked at as an island paradise full of potential economic enterprise for American banks, developers, and agriculture-based corporations as early as the 1950s. His writing continues to show that Oʻahu was purposefully remade to be the flagship representation of a tropical paradise as an island state by the government. The ocean and pristine coral reef systems became marketing tools to promote Hawaiʻi as a destination paradise.

Tourism and Hawaiʻi residents' behavior and activity have increased the coral reef ecosystem decline. Everything that passes through land ends up in the ocean. This includes potentially harmful chemical substances, such as fertilizers and herbicides, which can cause much damage and harm to the coral reefs (Damiani 2020). Human interaction has caused pollution and changed Oʻahu's shores. Today, Waikīkī and Shark's Cove have distinct differences. Recent efforts have worked to preserve and restore the damaged reefs. Some efforts saw no success, but efforts on the North Shore of Oʻahu have seen some success. This research focuses on why reefs are important, the threats to them, current conservation methods, and proposed sustainable solutions.

The Agricultural Effects on Coral Reefs

When Kānaka Maoli arrived in Hawaiʻi, the production of Hawaiian sugar cane began. For generations, native people cultivated their crops and used them to benefit the families in their local villages (Lincoln 2017). Unfortunately, this charitable way of life did not last long after foreigners stumbled upon the beautiful archipelago in 1778. In 1802, only 24 years after Captain Cook's voyage, the first sugar cane manufacturing plant

was established in Hawai‘i by the Chinese. Initially, the industry experienced slow growth, but after the United States' annexation of the Hawaiian Kingdom, the sugar cane industry began to boom (Mangelsdorf 1950). As the sugar cane industry grew, new agricultural techniques were developing. These advances resulted in the introduction of herbicides in the Hawaiian Islands.

Herbicides are chemicals used to remove undesired plants from an agricultural area. Plantation owners throughout the Hawaiian Islands, including O‘ahu, have been using these toxins to cultivate higher-quality crops since 1913. This quick and cost-effective solution for crop owners often leads to harmful side effects for the surrounding environment, and if they are not handled properly can even cause severe damage to the individual working with them. "From [1913], until about 1945, sodium arsenite in water was the main chemical used in sugar cane" (Hanson 1955). Sodium arsenite was the first herbicide introduced in Hawai‘i. It is capable of causing severe damage to humans by simply touching it. Just imagine the kind of irreparable damage chemicals such as this could do to the fragile ecosystems of Hawai‘i. Fortunately, this chemical's use was phased out, but others were introduced along the way. There are now numerous types of chemicals in use to support the high demand for agriculture (Thelin and Stone 2013). Thelin and Stone state that as plantation owners spray these chemicals into their fields, the chemicals go into the soil and, because of Hawai‘i's substantial amount of rainfall, end up in streams. Streams always lead to the ocean and bring with them anything that may have been washed away, including herbicides and damaged soils.

Montgomery (2007) shares how damaged and polluted soil becomes loose. There are many different factors that lead to soil degradation. Agriculture is one of these factors. Planting and removing crops from the same spot over and over again cause the soil to become loose and loses much of the nutrients contained within it. When soils become loose, they have been in use for a few years. This means that they are potentially chalked full of harmful chemicals. When herbicides enter the ocean, it harms the symbiotic algae found within reefs. Living corals have built symbiotic relationships with the algae (Sheppard et al. 2018). This means that the coral provides the algae with a safe space to live and photosynthesize, and the algae will help the coral by removing waste from the reefs. A decrease in algae can cause the health of the coral reefs to decrease, making them susceptible to other threats.

The input of sediment also causes another indirect effect on the coral reefs. When large amounts of sediments are dumped into the ocean, it clouds up the water. The murky water allows less sunlight to pass through the ocean. With less light available, the algae cannot perform photosynthesis.

An increase of sediments in the water not only causes the reefs to have less oxygen, because of being choked out by dirt, but also the reefs cannot have their waste removed by the helpful algae. Streams running sediments into the ocean also fill the shores with fresh water. A flood of a stream causes an excessive amount of freshwater to be mixed in with the ocean water. When this occurs, the water has a lower concentration of salt than it usually does. This is called hyposalinity. Hyposalinity allows harmful bacteria to grow and weakens the defense of the coral reefs, making them more susceptible to infection. (Health & Medicine Week 2018). These factors all harm the coral reefs, but they are not the only issues that negatively harm the reefs in Oʻahu.

Tourism's Toll on Coral Reefs

Upon the United States' acquisition of the Hawaiian archipelago in 1898, a new issue was introduced: tourism. Tourists from the United States had the impression that this land was an "island paradise," and businessmen saw it full of "economic opportunity" (Hitch 1958). Trask (1999) shares how she believes that tourism profits and proliferates off of commercializing, romanticizing, and sexualizing their people and culture. A majority of Kānaka Maoli despise the tourism industry. The United States' government works to blur the history of the Hawaiian Kingdom, fooling many American citizens into thinking that Hawaiʻi can be compared with states found on the North American continent. Much like the western United States prior to annexation, the Hawaiian Islands were seen as a blank slate, ready for development and with a population that required the assistance of the white man (Hitch 1958). This clear disrespect for native lands and spaces aggravate many Kānaka Maoli. As tourism continues to develop in Hawaiʻi, beachfront properties are built to attract foreign investments and, eventually, sell. In doing so, plants that once lived on the shores that kept sand in place are removed, causing much of the sand to be drug into the ocean. This process is known as erosion (Nargi 2022). Erosion causes detrimental effects on coral reefs.

The Negative Impacts of Tourism

In an interview with chief scientist, Daniel DeMartini of Kuleana Coral Restoration, identified the effects that tourism has had on Waikīkī. To attract and please tourists, sand was pulled from different beaches around the island of Oʻahu to help "restore" the beach that had disappeared due to urbanization and construction occurring on beachfront property.

FIGURE 1. **Shore of Waikīkī. (Reproduced with permission from *Hawai'i Magazine*, Wagner 2017.)**

The shore of Waikīkī looks dramatically different compared with today (Fig. 1). The beach now contains much less vegetation and significantly more buildings than in the early twentieth century. The dumping of recycled sand on the shores of Waikīkī caused dramatic changes to life under the sea. Recycling sand to the shores did not solve the issue, which is similar to placing a bandage on a bullet hole in hopes of healing the wound. The introduced recycled sand on the shores of the washed-out beach continues to be pulled back to sea. Sand continues to build up on the reef, choking out marine life. The commissioners only care about making the surface look good for the panoramic scenes tourists see in movies; they do not consult or consider the environmental or sustainable impacts on the space. Beach restoration has been effective, but the effects of this process on the coral reefs are not realized (Fig. 2). The sand on the beach always ends up on top of the coral reefs. According to Smith and Pai (1992), Kānaka Maoli believed that gods created the land and sea. It was the kuleana, or responsibility, of all Kānaka Maoli to care for both and all that was found within. This is a mindset that the commissioners of Oʻahu did not have when they made decisions regarding the shores. While Hawaiian lands were still in native hands, they observed the ecological changes that were occurring. Kānaka Maoli noticed how sometimes actions that made on the land changed interactions in the sea. When they fished, they paid careful attention to where they were and how many fish were present. This preserved the fishing areas and allowed them to continue fishing close to their homes. When foreigners entered the scene, the ahupuaʻa system, which was an ancient practice that saw

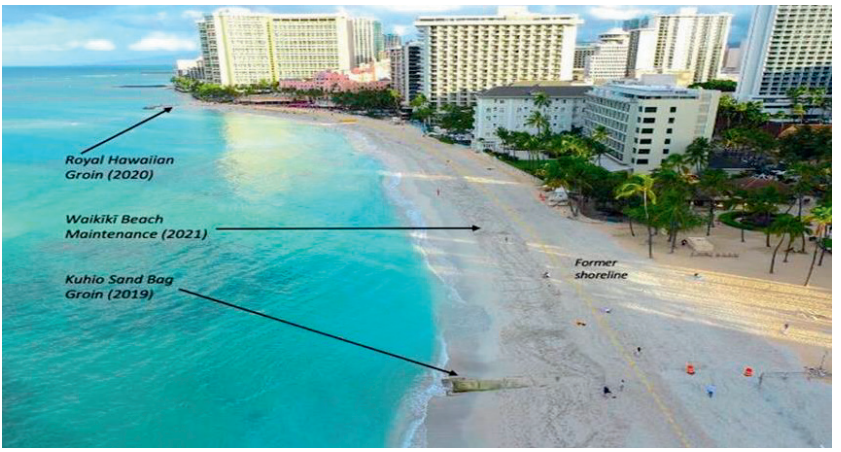

FIGURE 2. **Waikīkī sand restoration. (Reproduced with permission from KITV News, Doorey 2022).**

the connection between the land and the sea, was replaced by foreign interests in the growth of money and individualism obliterating the ahupuaʻa system and stewardship toward each other and the land-sea relationship to humans.

Commercial and government interests erase Hawaiian culture and the values embedded in historic Kānaka Maoli spaces then and now, including the belief that the coral polyp was the first living organism created (Siler 2012; Liliʻuokalani 1978). This can be interpreted as coral being the foundation of life throughout the archipelago. DeMartini emphasizes the amount of time it requires for the coral polyp to become a coral colony. The polyp grows at a rate between 0.3 and 2 cm every year, taking hundreds of years to become the massive colonies they are today (Fig. 3). Coral colonies are literally living history and have surrounded Oʻahu longer than any person who has ever set foot on the island. This truth is often not understood by visitors and sometimes, locals (DeMartini).

A Potential Solution

Many visitors, short-term residents, and long-term residents do not seek to harm the fragile ecosystems of the island, but harm occurs. One way to prevent this damage is through better educational methodologies specifically to enhance knowledge of coral reef and stewardship interaction between land, humans, and sea. This can be tackled by both the state and local residents. Signage explaining not to walk on or take from coral reefs will help people to

FIGURE 3. **Healthy coral colony. Coral colony started as a single polyp growing only a few centimeters a year. (Reproduced with permission from Kuleana Coral Restoration.)**

understand that their actions have negative impacts on fragile ecosystems such as the reefs. Educated local residents can help by educating others, but the situation must be approached in a stern but nonthreatening manner. Friends and acquaintances have had unpleasant encounters with locals when they unintentionally damage reefs and local or sacred lands. The anger and yelling make them inclined to continue with the harmful behaviors, whereas those who are treated kindly and softly informed of their ignorance are quick to change their ways and want to become better. Helping people understand the consequences of their actions can help people change the way they treat these living ancient artifacts.

Comparing Oʻahu Shores and How They Can Be Restored

The presence of agriculture and tourism has led to soil degradation across the island. These soils are loose and fall into the coral reefs found on Oʻahu. Different sides of the island experienced different kinds of change because of the impacts of tourism and agriculture. The first location that comes to mind has already been mentioned: Waikīkī. Waikīkī has seen tremendous change and cannot even be recognized as the place it once was. This area, when compared with the Pūpūkea Marine Life Conservation District, composed of Pūpūkea (Sharks Cove), Kalua o Maua (Three Tables), and Waimea, is in horrific condition.

The reason for this drastic difference is the amount of tourism the shores see. Tourism always brings pollution. The more tourists in an area, the more

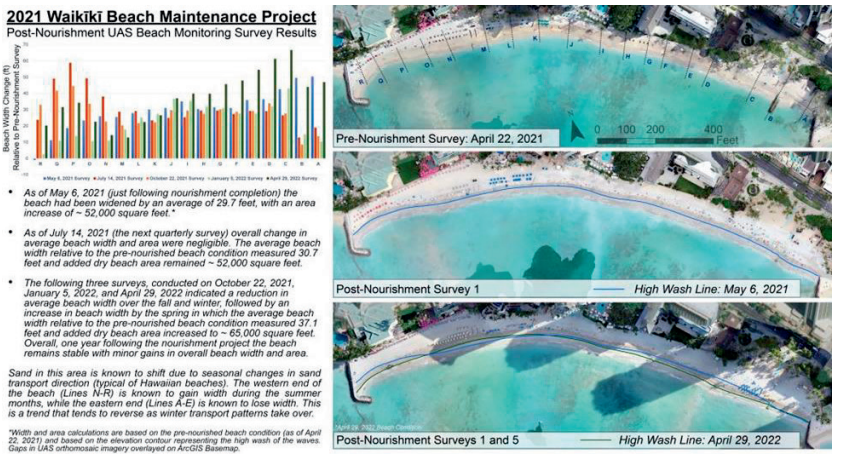

FIGURE 4. **Postnourishment survey of Waikīkī. (Reproduced with permission from University of Hawai'i 2022.)**

polluted an area becomes. According to Hotels.com, there are 4,261 hotels found in Waikīkī. The Pūpūkea Marine Life Conservation District has zero. In Waikīkī, there is a lack of marine life and coral in the water. When snorkeling at Pūpūkea, the waters appear nearly crystal clear, bursting with marine life in every crevice. Fortunately, restoration can still be done at both locations; however, when working on restoration, it is important not to impose a rural system on an urban environment and vice versa. More simply put, conservation efforts in Waikīkī and Pūpūkea look extremely different.

In May 2021, 21,700 cubic yards of eroded sand were brought from the ocean to the shore. This project is expected to be recurring every five to ten years (University of Hawai'i 2022). This helps keep the beach present and picture perfect to help increase tourism. DeMartini shares how this method helps keep the beaches looking beautiful but plays a negative effect on the coral reefs. The sand moved to the shore recedes into the ocean by the waves and washes into the coral reefs and smothers them. Figure 4 shows that within a year's time, the beach grows wider due to erosion occurring on the shores. Waikīkī seems to be a hopeless case because the government continues to maintain the beach for tourists and pays no regard to the reefs underneath. The best method to help preserve the life left is to limit the amount of pollution. Everyone must be consciously aware of the damage they may be doing. It is imperative that people restrain from leaving trash on the shores and use reef-safe sunscreens. These seemingly small actions will go a long way in preserving coral reefs. Although Waikīkī can easily discourage environmentalists, Oʻahu's North Shore offers hope.

The Pūpūkea Marine Life Conservation District lies in much better condition, but it still faces similar threats. Sedimentation is an ever-looming threat because the Waimea River feeds into Waimea Bay. Additionally, tourists flock to this district because of its picture-perfect postcard appearance. Waimea Bay has been better at combating tourism because of its rural location. Local residents of Oʻahu's North Shore constantly fight against the addition of new development, which means that new resorts are scarcely ever built. The most recent construction was Turtle Bay Resort, located seven miles north of Waimea, in 1972.

In marine environments, marine biologists and activists often jump into creating marine protected areas (MPAs). MPAs can help restore the native ecosystems in an area, help create sustainable fisheries, assist in education, and even boost the economy (Young 2005). Among these benefits, MPAs still have their fair share of drawbacks. These spaces limit the amount of commercial activity occurring in the protected zone, but they often restrict access to ancestral lands, traditional fishing, and specified waters. MPAs do not have a history of ever returning to what they once were. Once they are put into place, they tend to remain this way for decades with no plan to allow the same kind of access that was once available. Additionally, MPAs can cause overcrowding. This is most evident on Oʻahu at Hanauma Bay. In 1967, Hanauma Bay was established as an MPA. Prior to the COVID-19 pandemic, 3,000 people would visit the bay to see the coral reefs and other marine life each day. Over time, this caused a decline in the success of the coral reef ecosystems. Establishing an MPA in Hanauma only curved the damage done but failed to prevent it. MPAs can be beneficial but only by preventing all access to the area. This would not work. Instead, preserving the coral reefs on the island requires actions, such as beach cleanups, blackout fishing dates, and preventing harmful chemicals from entering the ocean, taken by the state, local residents, both Kānaka Maoli and haole, and tourists.

Conclusions

Kānaka Maoli have cared for and cherished coral reefs and the life-forms that thrive alongside them for generations. They used their ahupuaʻa system to care for the land from the mountain tops to the ends of the reefs. When foreigners stumbled upon the Hawaiian archipelago, these ancient and effective practices were replaced by Western beliefs that included forsaking care of the ocean and its reefs. As foreigners continued to seize native lands, the damage increased exponentially. It is now the duty of local residents, tourists, and the Hawaiʻi state government to play their part in combating the damaging effects of herbicides, sedimentation, pollution, and tourism on coral reef ecosystems. Local residents and the state government must better educate the tourists who enter this space as a guest. In the end, educational efforts mean nothing if the tourists fail to follow guidelines shared.

Conservation methods on Oʻahu look different on various shores. More rural areas have different needs and use conservation models that prove incredibly ineffective in urban environments. The same can be said about urban models in rural environments. Common conservation methods often include the establishment of MPAs. They have the potential to be beneficial and help the marine ecosystems; however, some of them, such as at Waikīkī, do more harm than good to the native ecosystems. They create a beautiful surface but slowly deteriorate the reefs underneath. Working with local communities to decide what works for the area is a much more practical method of preserving coral reef ecosystems. When working with communities, it is important to understand why coral reefs are significant to them.

The coral reefs are in grave danger and are no longer being cared for as part of land management systems. More effective conservation methods must be adopted to preserve coral reefs. They are the basis of life found within the ocean and house life that has helped feed the people of this planet for generations (Sheppard et al. 2018). Although the reefs cannot be viewed from the surface, this does not discredit the importance of them. If the coral reefs are not saved, the repercussions will be horrific. Pollution within the ocean will increase. Thousands of marine species will go extinct. The ocean itself will be considered dead. The coral reefs must be saved, but they cannot save themselves. People need to speak up for the reefs and play their part to ensure protection.

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